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Original article

Supramalleolar osteotomy: Techniques, indications and outcomes in a series of 83 cases

F. Colin^{a,*}, F. Gaudot^b, G. Odri^a, T. Judet^b^a Clinique Chirurgicale et Traumatologique CCOT, CHU Hôtel-Dieu, 1, place Alexis-Ricordeau, 44000 Nantes, France^b Service de Chirurgie Orthopédique, Hôpital Raymond-Poincaré, 104, boulevard Raymond-Poincaré, 92380 Garches, France

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ABSTRACT

Introduction: Supramalleolar osteotomy is an alternative surgical procedure for the management of asymmetric early arthritis of the ankle. The main goal of this retrospective study was to evaluate the clinical and radiological benefits of supramalleolar osteotomy. The secondary goal was to identify prognostic factors to help decide upon this therapeutic indication.

Materials and methods: Eighty-three patients, mean age 45 years old (17–79), presenting with post-traumatic asymmetric early arthritis of the ankle were followed up for a mean 3.5 years (1–14 years). Sixty-two patients presented with a varus deformity (mean: 13°), and 21 with a valgus deformity (mean: 17.5°). The presence of a preoperative clinical 'sidewalk sign' was looked for and it was considered positive if pain improved when the patient walked on a surface slope that was tilted in the opposite direction of their deformity. A functional preoperative evaluation and at the final follow-up were performed using the American Orthopedic Foot and Ankle Society (AOFAS) ankle-hind foot scale. The frontal deformity was measured by the Meary angle on a weight-bearing X-ray. Varus deformities were treated by a lateral closing wedge supramalleolar osteotomy or a medial opening wedge supramalleolar osteotomy. Valgus deformities were treated by a lateral opening wedge or a medial closing wedge supramalleolar osteotomy.

Results: At last follow-up, the mechanical axis in the varus group was 1.3° and 7.5° in the valgus group. The AOFAS score significantly improved ($P < 0.001$) by 15 points in patients with a varus deformity and 13 points in patients with a valgus deformity. A positive sidewalk sign (disappearance of pain) was correlated with a good outcome and had a positive predictive value of 0.88 (CI: 0.77–0.95) ($P < 0.001$).

Discussion: The supramalleolar osteotomy is a conservative therapeutic surgical option for the management of arthritis of the ankle associated with varus or valgus deformities. The results are satisfactory for indications of arthritis with varus and valgus deformities and a positive 'sidewalk' sign (pain relief on a slope surface tilted in the opposite direction of the deformity).

Level of evidence: Level IV; retrospective case series.

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1. Introduction

In 70% of cases, arthritis of the ankle is post-traumatic and therefore affects younger patients than those with hip or knee arthritis, which is more often degenerative [1,2]. Conservative treatment options should therefore be chosen whenever possible in the former cases. Although supramalleolar osteotomy is a conservative therapeutic surgical option in patients with tibiotalar arthritis with hind foot alignment (varus/valgus) deformities [1,3–11], this

apparently logical option is not well known because it is difficult to evaluate due to its many different clinical presentations (type of deformity, degree of deformity, underlying foot deformities, difficulty of obtaining measurements, post-traumatic as well as neurological etiologies and malformations) as well as the many different correction techniques used. Moreover, the limit between an indication for an osteotomy and for non-conservative treatment (prosthesis and arthrodesis) has not been clearly established.

In this study, we took one approach and used standardized surgical techniques to create a homogenous group of patients for evaluation.

The main goal of this study was to evaluate the anatomical results, the morbidity and the intermediate term functional results

* Corresponding author. Tel.: +33 06 07 37 31 07.

E-mail address: fabricecolin1@gmail.com (F. Colin).

of supramalleolar osteotomy. The secondary goal was to identify prognostic factors to more clearly define the indications for this therapeutic option.

2. Materials and methods

This was a continuous retrospective analytical single-center study performed in the orthopedic surgery unit of the Raymond-Poincaré Hospital, Garches, France.

All patients presenting with post-traumatic symptomatic arthritis of the ankle associated with a coronal plane deformity were included in the study.

Patients presenting with neurological, rheumatoid and/or infectious diseases were excluded from the study as well as patients who had already undergone sub- or mid-talararthrodesis and patients with less than 1 year of follow-up.

2.1. Population

Between 1988 and 2011, 83 corrective supramalleolar osteotomies were performed in 83 patients. During this period, approximately 700 tibiotalarthrodeses and 400 total ankle replacements were performed. There were 24 women and 59 men, mean age 45 years old at surgery (17–79). The mean follow-up was 3.5 years (1–14). A total of 38 patients were excluded from the study.

Two groups were studied according to the deformity:

- varus deformity: $n=62$ (44 men, 18 women, 50 years old [17–79]);
- valgus deformity: $n=21$ (15 men, 6 women, 37 years old [22–62]).

2.2. Method of evaluation

The clinical and radiological assessments were performed during the preoperative assessment and at the final follow-up.

The clinical assessment was based on the American Orthopedic Foot and Ankle Society (AOFAS) ankle-hind foot scale [12]. We arbitrarily created two groups: those with AOFAS scores below 65 points (poor results) and above 65 (average and good results). We questioned patients about the presence of a “sidewalk” sign in the preoperative assessment. This was considered to be positive if pain improved when the patient walked on an inclined plane that was slanted in the opposite direction of their deformity. The ankle was less painful on a left slanting sidewalk in a right varus ankle or in a left valgus ankle with a transverse slant of between 2 and 4%. This sign could also be simulated by creating a padded orthopedic insole (a pronated insole for a varus deformity, supinated insole for a valgus deformity).

The weight-bearing X-rays included an AP, lateral and AP with internal rotation as well as a Meary view. These were analyzed by an independent observer (F.C.).

The stage of arthritis was classified according to Takakura et al. [1]:

- stage 1: osteosclerosis and osteophytosis with no sign of narrowing of the joint space;
- stage 2: incomplete medial or lateral narrowing of the joint space;
- stage 3: limited medial or lateral narrowing of the joint space in contact with subchondral bone;
- stage 4: obliteration of the entire joint space resulting in bone contact throughout entire ankle.

The degree of coronal plane deformity of the hind foot was measured by a Meary angle with the Dijan and Annonier method [13]

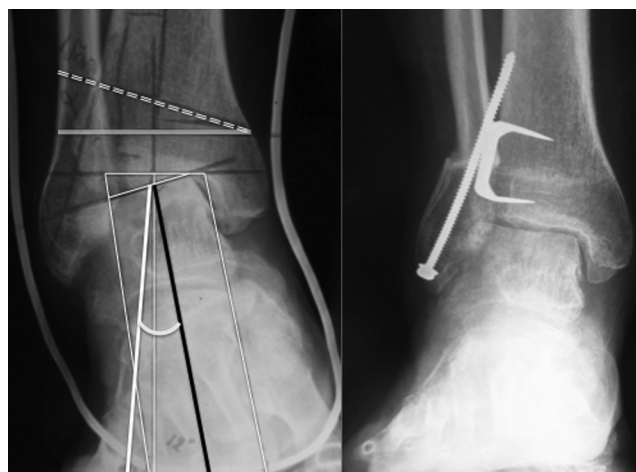


Fig. 1. Full weight-bearing Meary view. Hind foot alignment assessment by the Dijan-Annonier method. Same case report as Fig. 1. Hind foot alignment indicated by the black line. Goal of correction indicated by the white line. The level of the osteotomy is defined arbitrarily by the double white line. The level of resection is defined reporting the angle of correction with the dashed white line.

(Fig. 1: angle formed by vertical line perpendicular to the floor drawn from the middle of the tibiofibular mortise and the line that joins the middle of the mortise to the middle of where the heel is in contact with the ground). Normal results are 0 to 8° valgus [14]. The targeted correction was 5° valgus.

The joint space slant was measured (Fig. 2):

- on the frontal plane, by the Tibial Articular Inferior Surface (TAS) angle formed by the mechanical axis of the tibia and the tangent of the tibial plafond on an AP view. It is normally 89° on the medial side of the ankle;
- on the lateral plane, the Tibial Lateral Surface (TLS) angle is formed by the mechanical axis of the tibia and the line passing through the ends of the tibial articular surface in a lateral view. It is normally 81°.

Tibiotalar congruence was evaluated by the Talar Tilt (TT) angle. This angle is formed by the tibial articular surface and the talar articular surface on an AP X-ray. It is normally less than 4°.

These measurements were used to anatomically define the type of alignment deformity and the type of supramalleolar osteotomy:

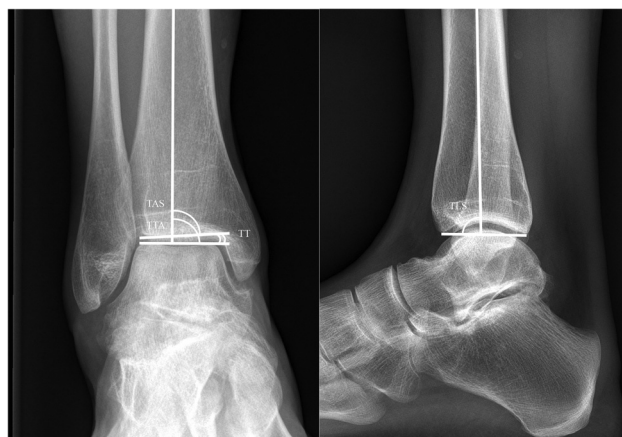


Fig. 2. Articular inferior tibial and talar surface angle measurement on frontal and lateral ankle radiographs. TAS: tibial articular inferior surface; TLS: tibial lateral surface; TT: talar tilt.



Fig. 3. AP X-ray of a lateral closing wedge supramalleolar osteotomy of the ankle. TAS = 82°; TT = 14°; Meary = 12° (preoperative varus). TAS = 99°; TT = 1°; Meary = 8° (postoperative varus).

- corrective osteotomies ($n=50$), for extra-articular deformities (tibial malunion, epiphyseodesis) that were often more severe due to joint space narrowing. The configuration of the bi-malleolar area was abnormal. The TAS angle was abnormal. There was very little change in the TT angle;
- palliative osteotomy ($n=33$), for intraarticular deformities with chondral wear, notching and ligament distension (ligament laxity on the convexity and tibial plafond impaction wear on the concavity of the deformity), which are often sequella from chronic instability. The configuration of the bi-malleolar area was normal. The TAS angle was normal, the TT angle was abnormal.

2.3. Treatment

2.3.1. Sixty-two varus deformities (44 men, 18 women)

Treatment of a varus deformity was a lateral closing wedge osteotomy in 41 cases and a medial opening wedge osteotomy in 21 cases.

The lateral closing wedge osteotomy was chosen except in the presence of a post-traumatic leg length discrepancy of more than 1 cm, or if there was a contraindication in the soft tissues (existing scars or skin damage).

The osteotomy cut was between 10 and 15 mm above the joint space to facilitate union, allowing minimal osteosynthesis and preventing bayonet deformities.



Fig. 5. AP X-ray of a medial opening wedge supramalleolar osteotomy of the ankle. Preoperative TAS = 88°; TT = 6°. TAS = 100°; TT = 1°.

A prefibular Blount staple was used to stabilize the tibial osteotomy. The fibula was attached by (3.5 mm) ascending compression screw fixation (Figs. 3 and 4).

The 5 cm medial opening wedge cut was performed by a medial approach. The desired correction was obtained with a tricortical iliac graft. Graft stability obtained by spontaneous compression from tightening of the soft tissues, often made additional internal fixation unnecessary, otherwise a staple was added (Figs. 5 and 6).

2.3.2. Twenty-one cases of valgus deformity (15 men, 6 women)

Valgus deformity was treated with a medial closing wedge osteotomy in 12 cases and a lateral opening wedge osteotomy in 9 cases.

For the medial closing wedge osteotomy, a low cut was made for the tibial bone resection that was basically parallel to and less than 15 mm from the joint space. The fibular cut was the same as for the opening wedge procedure. The osteotomy was stabilized with one or two osteotomy staples.

The indication for the lateral opening wedge osteotomy was rare, and was associated with the necessity of lengthening the fibula, either by an interposition bone graft or a long oblique osteotomy. The cut, graft and tibial stabilization were similar to that for a medial opening wedge osteotomy.

2.3.3. Associated procedures

To obtain a plantigrade (flat) stance, certain patients required additional surgical procedures. Percutaneous lengthening of the Achilles tendon was performed in an equinus ankle in 5 cases of

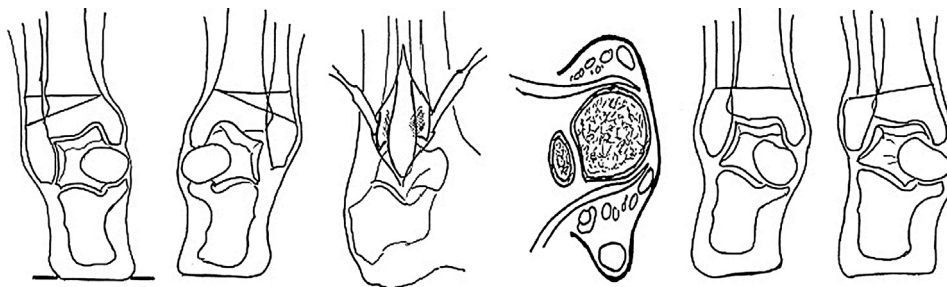


Fig. 4. Closing wedge supramalleolar osteotomy: preoperative planning of closing wedge osteotomy; preoperative planning of palliative closing wedge; lateral view of retractor; position of retractor, transverse cross-section; normal anatomical ankle restored with supramalleolar osteotomy; slanted ankle joint as a result of palliative osteotomy.

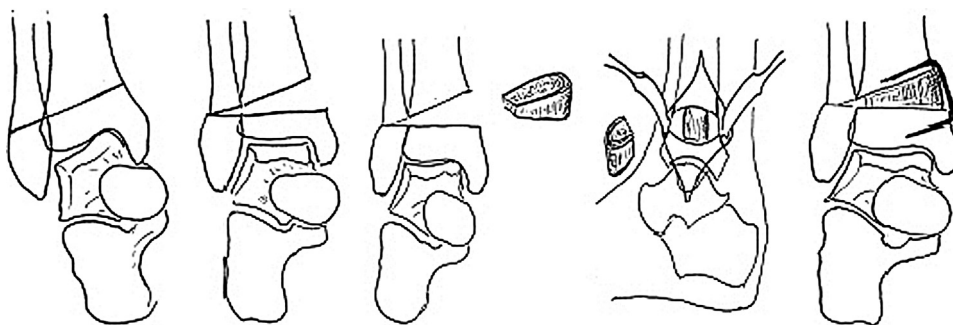


Fig. 6. Medial opening wedge supramalleolar osteotomy, from left to right: preoperative planning of opening wedge; medial opening wedge with tricortical iliac crest bone graft; medial view of bone graft; internal fixation with staple.

varus deformity, subtalar arthrolysis for severe stiffness in 2 cases and procedures on the forefoot in 3 cases of claw toe.

2.3.4. Rehabilitation program

The patients were immobilized for 6 weeks in a plaster cast. When the medial cortex was intact, weight bearing was allowed after 3 weeks long as a walking boot was worn.

2.4. Statistical analyses

An Excel (Microsoft®) spreadsheet was created for all data, which were made anonymous according to the guidelines from the French National Data Protection Commission (CNIL). Clinical measurements were obtained in a consultation with a senior author, radiological measurements were obtained by an independent operator (F.C.). The statistical analysis was performed using SPSS v.20.0 (SPSS IBM, Armonk, New York, USA) software. Quantitative variables were analyzed by descriptive statistics (mean, median, standard deviation). Comparison of quantitative variables was obtained by non-parametric tests (Kolmogorov-Smirnov normal distribution test, Wilcoxon test) or parametric tests (Fisher exact test). Qualitative variables were analyzed by the χ^2 test. We analyzed clinical failures, revisions and good results to identify prognostic criteria for the postoperative clinical outcome of osteotomy (sidewalk sign, degree of the deformity and Meary angle, stage of arthritis and Takakura score) using the Pearson correlation coefficient r . $P < 0.05$ was considered to be significant.

3. Results

There were no perioperative complications. There were no vascular or nervous complications. All complications are described in Table 1. Radiological union (disappearance of the osteotomy line with bridging by trabecular bone) was obtained after a mean 11 weeks (8–24). There was no significant difference in the time until union, clinical or radiological results in relation the type of osteotomy.

Table 1
Postoperative complication and surgical revision.

Axis	Complication	Age	Takakura (preoperative)	OSM	Internal fixation	Union (months)	Time until revision	Type of revision
VR	Impingement	28	1	FE	Staple	3	5 years	IR
VR	Scar dehiscence	54	2	OI	Staple	4	1.5 months	IR
VR	Overcorrection	63	2	FE	Staple	6	2 years	Desis
VR	Arthritis	64	3	OI	Staple	3	8 years	Desis
VR	Non-union	64	3	OI	None	–	1 year	Desis
VL	Septic non-union	62	1	OE	Plate	–	6 months	Desis
VL	Sepsis	22	1	FI	Fixation	3	3 months	Lavage

VR: varus; VL: valgus; OSM: osteotomy; FE: lateral closing wedge; OI: medial opening wedge; FI: medial closing wedge; Desis: arthrodesis; IR: implant removal.

3.1. Varus group

The AOFAS score improved by 15 points, from a mean preoperative score of 58 (0–84) to 73 (36–100) points at follow-up ($P < 0.001$) (Table 2). The Meary angle went from 13° varus (1°–30°) to 1° valgus (12° valgus–23° varus). There was significant correction of the TAS and TT; mean postoperative values were normal ($P < 0.001$). There was no significant change in the TLS angle. The radiological Takakura score improved significantly ($P < 0.003$) (Tables 2 and 3).

3.2. Valgus group

The AOFAS score improved by 13 points, from a preoperative score of 66 (27–85) to 80 (58–100) at the final follow-up ($P < 0.001$). The Meary angle went from 17° valgus (10°–30°) to 8° valgus (16° valgus–5° varus). There was significant correction of the TAS. There was no change in TT. The TLS angle was normal and there was no postoperative change. The radiological Takakura score did not change (Tables 2 and 3).

There was no significant correlation between pre- and postoperative TT angles and clinical results (R squared close to 0).

There was no correlation between the severity of the preoperative deformity (Meary angle), the type of deformity (TT), the stage of preoperative arthritis (Takakura score), and the postoperative AOFAS score at follow-up.

There was a significant correlation between the clinical sidewalk sign and a postoperative AOFAS score above 65 ($P < 0.001$). The sensitivity of this test was 0.85 (0.74–0.93) with a positive predictive value of 0.88 (0.77–0.95), a negative predictive value of 0.59 (0.36–0.79) and an Odds Ratio of 11.1 (3.4–35.5).

4. Discussion

Our results confirm the interest of supramalleolar osteotomies in the conservative surgical treatment of arthritis of the ankle with frontal alignment deformities, whatever the initial deformity (valgus or varus) and whether the primary deformity is osseous or articular. This procedure results in good anatomical correction,

Table 2
AOFAS score assessment.

	Preoperative		At revision		P
	Mean	SD (Min–Max)	Mean	SD (Min–Max)	
VR pain (/40)	20	± 6 (0–30)	27	± 6 (20–40)	<0.001
VR function (/50)	31	± 8 (8–45)	36	± 9 (0–50)	<0.001
VR alignment (/10)	7	± 2 (0–8)	10	± 1 (0–10)	<0.001
Varus AOFAS total (/100)	58	± 16 (0–84)	73	± 13 (36–100)	<0.001
VL pain (/40)	21	± 7 (0–30)	29	± 7 (20–40)	<0.001
VL function (/50)	38	± 8 (0–45)	41	± 6 (8–50)	<0.001
VL alignment (/10)	7	± 2 (0–8)	10	± 1 (8–10)	<0.001
Valgus AOFAS total (/100)	66	± 14 (27–85)	80	± 13 (58–100)	<0.001

VR: varus; VL: valgus.

few complications and improved clinical functional scores at follow-up. Rebalancing, shifting and redistributing articular loads and stresses improved joint space narrowing and significantly improved the Takakura radiological arthritis score in varus deformities. A significant correlation was found between the clinical sidewalk sign for this indication and the postoperative clinical results.

Nevertheless, this study has certain limitations: in particular the different etiologies (bone or ligament trauma), deformities, and surgical techniques. The radiological assessment by a single observer and the use of a non-validated clinical score can also be considered a source of bias [15].

On the other hand, there is a certain homogeneity to this continuous study [16]: the indications are based on a decisional tree that did not change over time. The clinical sidewalk sign was shown to be a useful tool for confirming the surgical indication. Walking on an incline that is slanted in the opposite direction of the deformity recreates the desired effect of a supramalleolar

osteotomy. Persistent pain when walking on this incline (or the use of a padded insole to create the incline) is predictive of a poor result of the supramalleolar osteotomy and could be an indication for more invasive surgery (arthroplasty or arthrodesis).

Osteotomies should be categorized according to whether they are “corrective” or “palliative”. The therapeutic strategy should be considered when creating an oblique joint space and/or malleolar malunion in corrective osteotomies. It would be difficult to perform arthroplasty in these cases. On the other hand, the mechanical axis must absolutely be corrected by a corrective osteotomy first before performing ankle replacement.

Our series is important for two reasons compared to the publications in the literature. It included a large number of varus deformities ($n=43$) treated by lateral closing wedge osteotomies. To our knowledge, this is the largest study of this type to date. Second, unlike other published studies we did not find any correlation between the severity of the interarticular deformity (TT) and postoperative clinical results.

Table 3
Pre- and postoperative clinical and radiological assessments at the final follow-up.

	Preoperative		Postoperative		P
	Mean	SD (Min–Max)	Mean	SD (Min–Max)	
Varus deformity					
Takakura Score	1.9	± 0.7 (1–3)	1.6	± 0.6 (1–3)	<0.01
Meary angle	VR 13°	± 6 (1–30)	VL 1.3°	± 8 (12VG–23VR)	<0.001
TAS angle	76°	± 9 (53–103)	91°	± 8 (68–106)	<0.001
TT angle	6°	± 8 (15–33)	1°	± 3 (0–17)	<0.001
TLS angle	79°	± 8 (36–87)	80°	± 7 (55–89)	= 0.56
Valgus deformity					
Takakura Score	1	± 0.22 (1–2)	1.1	± 0.3 (1–2)	= 0.99
Meary angle	VL 17°	± 5 (10–30)	VL 7°	± 5.5 (VR 5°–VL 16°)	<0.001
TAS angle	102°	± 13 (62–121)	91°	± 4.8 (81–102)	<0.001
TT angle	1°	± 3 (2–10)	0°	± 1 (0–3)	= 0.09
TLS angle	80°	± 7 (61–89)	80°	± 6 (68–88)	= 0.97

VR: varus; VL: valgus; TAS: tibial articular inferior surface angle; TLS: tibial lateral articular surface angle; TT: talar tilt.

The medial opening wedge osteotomy is the usual surgical option for varus deformities in the literature [1,4,5,7,9,17]. Harstall et al. reported a small series of 9 lateral closing wedge osteotomies [8]. We preferred the lateral closing wedge osteotomy because it has the advantage of limiting tension in the soft tissues, which is a source of incisional healing complications [7]. Moreover, the closing wedge osteotomy allows partial and even total weight bearing because it is highly stable, with minimal internal fixation. It avoids the loss of correction that is sometimes found with large medial opening wedge procedures. The lateral closing wedge procedure has the disadvantage of creating shortening if it is larger than 1 cm. A medial opening wedge procedure is indicated if there is a pre-existing leg length discrepancy. Technically a low osteotomy cut close to the center of rotation of the ankle should limit the risk of bayonet deformities. Myerson et al. proposed a corrective osteotomy cut at the level of the center of rotation of the deformity [18]. However, an osteotomy on a diaphyseal malunion is more difficult because reference points are lacking, and the quality of union and stability is also poorer [18].

Unlike the results reported by Lee et al. [4], we did not find any correlation between the functional AOFAS score and the tibiotalar angle. Mean TT was 6° with a maximum of 33° in our series. This intraarticular deformity was frequent in patients with a history of recurrent sprains and was the cause of arthritis across from the medial hind foot compartment, which is defined as varus arthritis. Radiological assessment showed significant correction of initially abnormal angles (TAS, TT, Meary), but as in most published series, correction did not restore tibiotalar congruence because TT at follow-up was still above normal [19]. Nevertheless, the functional AOFAS score was significantly improved. For Knupp et al. [3,19], the radiological assessment corresponds to a static assessment, and a supramalleolar osteotomy results in a modification of the vectors of stress on the Achilles tendon which allows rebalanced distribution and shifting of intraarticular loads and stresses during effort. This mechanical realignment of loads relieves stress on the areas of degenerative arthritis across from the medial compartment of the tibiotalar joint [3,19]. Therefore in this series, the intraarticular deformity was not a negative predictive factor. Long-term follow-up evaluation of patients with joint incongruence would be interesting.

5. Conclusion

Supramalleolar realignment by either corrective or palliative osteotomy provides satisfactory short- and intermediate-term clinical results. This is a simple, reproducible surgical technique. The clinical sidewalk sign (pain relief on an inclined plane slanted in the opposite direction of the deformity) is easily and rapidly performed. A positive sidewalk sign is a predictive factor of a good outcome for this conservative realignment osteotomy. In the presence of difficult cases (elderly patients with a high level of physical activity, advanced arthritis, severe intraarticular deformities), a positive

clinical sidewalk sign provides additional support for a supramalleolar osteotomy.

Long-term follow-up of these cases could provide an evaluation of survival of this procedure and the rate of revision with arthrodesis or arthroplasty, in particular in cases of arthritis with a varus deformity, sequellae from chronic instability.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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